TP 6146E

TRAIN DATA RECORDING SYSTEM
PHASE III
LABORATORY AND FIELD TEST SUPPORT

Prepared for the
TRANSPORTATION DEVELOPMENT CENTRE
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by

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The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre.

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17. Abstract

This report describes the third phase of a four-phase research and development project aimed at developing a completely solid state, microprocessor - controlled train data recording system (TDRS). The support activity consists of familiarization of personnel involved in an independent environmental laboratory evaluation and separate field trials of system components, trouble-shooting, engineering redesign, hardware modifications and software enhancements dictated by the initial test findings during calendar year 1984.

The locomotive-based recorder unit and auxiliary sensors experienced the following problems:

1) Low voltage power supply during cold weather engine cranking
2) Transient protection overload
3) Traction motor current shunt failure

Remedial action was taken to alleviate the latter two problems encountered. The power supply voltage level fell outside of the recorder specifications and the resultant shut-down and loss of memory data could not be attributed to an equipment design weakness but will be addressed in phase IV of the project.

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17. Résumé

Ce rapport concerne la troisième étape d'un programme de recherche et de développement en quatre phases visant la réalisation d'un système d'enregistrement des paramètres de fonctionnement des trains, commandé par microprocesseur et entièrement transistorisé. Il s'agissait de permettre aux divers personnels intéressés de mieux connaître le système, notamment les techniciens du laboratoire indépendant chargé des essais climatiques et pratiques du système, ceux chargés du dépannage, de la réétude et de la modification du matériel, ainsi que ceux responsables de perfectionner sur les logiciels à la lumière des résultats de la première série d'essais menée en 1984.

Ces essais ont révélé les faiblesses suivantes:

1) trop basse tension d'alimentation du système lors des démarrages par temps froid,
2) insuffisance des protections contre les surtensions transitoires,
3) défaillance du conditionneur du signal transmis par le détecteur de courant de traction.

Les deux derniers problèmes ont été corrigés. Quant à l'arrêt intempestif du système et à l'effacement consécutif des données en mémoire, ils résultent d'une tension d'alimentation inférieure à la valeur indiquée dans la fiche technique de l'enregistreur et non d'une défaillance quelconque du système lui-même. Il a été décidé de s'attaquer à ce problème durant la phase IV du programme.

18. Mots-clés	19. Diffusion
Rail, train, locomotive, enregistreur de données, microprocesseur, traitement informatique	Le Centre de développement des transports dispose d'un nombre limité d'exemplaires

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TABLE OF CONTENTS

	PAGE
1. INTRODUCTION	1
1.1 Objectives	2
1.2 Scope	3
2. PHASE III FIELD TESTS AND LABORATORY SUPPORT	5
2.1 Work Statement	5
2.2 Environmental Laboratory Support	6
2.3 Field Trials	7
3. CONCLUSION	11
Appendix A Electrical Specifications for Transient Absorption Zener	13

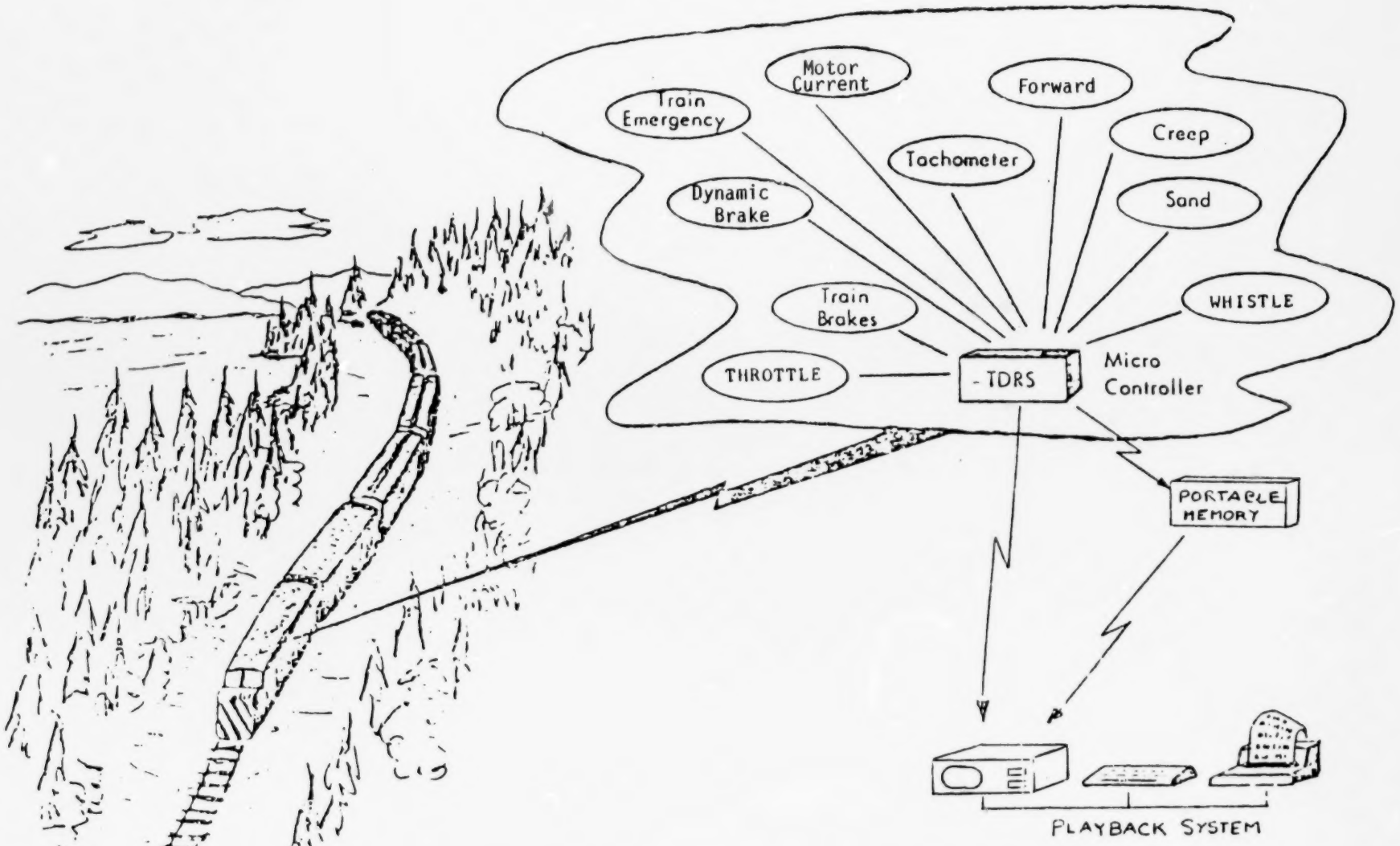


FIG. 1: APPLICATION DIAGRAM - TRAIN DATA RECORDING SYSTEM - (TDRS)

1. INTRODUCTION

Over the past ten to fifteen years, a few U.S. and Canadian railways experimented with event recorders in diesel-electric locomotives which were used to record speed, elapsed time and distance and from two to eight or more other train operating events such as forward and reverse, throttle positions, automatic and independent brake pipe pressure, dynamic brake and traction motor current, wheel slip, sanding application, etc., over a period up to 48 hours. Early train data recording equipment employed magnetic tape technology for data storage and suffered frequent mechanical failures attributable to the harsh locomotive operating environment.

A need for rugged, reliable and economic train data recording equipment was firmly established and reinforced by recommendations pertaining to the use of «crash recorders» contained in the report of public inquiry of a train derailment in western Canada in December 1980.

MPB Technologies Inc., with the cooperation and endorsement of Canadian Pacific Railway (CPR), responded to the need by proposing to develop an all solid state microprocessor controlled train data recording system (TDRS) in early April, 1981. The system would employ a recorder mounted in the locomotive, optional CRT or equivalent display and keyboard unit for the engineman, playback unit consisting of a keyboard control, colour CRT monitor, dual floppy disk drives and optional printer in a fixed location and a portable memory transfer unit.(See Fig. 1) The proposal was accepted and sponsored by the Transportation Development Centre, Transport Canada, with some initial funding provided by the Department of Supply and

Services under their unsolicited proposal program.

A comprehensive development project was implemented with the objective of producing a final design package suitable for manufacturing all newly developed components. Phase I of the project included the preliminary design, fabrication and functional testing in both the laboratory and in a C.P.R. locomotive of a «breadboard» prototype recorder and portable memory unit. System design modifications were made in Phase II and prototype units were fabricated for more extensive laboratory environmental and field trials by the Fall of 1983. Phases I & II are documented in report TP5105E entitled «TRAIN DATA RECORDING SYSTEM, FINAL REPORT» dated May, 1984.

In November 1983, MPB Technologies responded to a Request for Proposal initiated by the Transportation Development Centre (TDC) requesting engineering design support for the prototype TDRS equipment undergoing performance evaluation in both the Warnock Hersey laboratory in Toronto and in C.P. Rail's locomotive number 6022 operating out of their Cote St. Luc maintenance shop.

This report addresses only the Phase III engineering support activity.

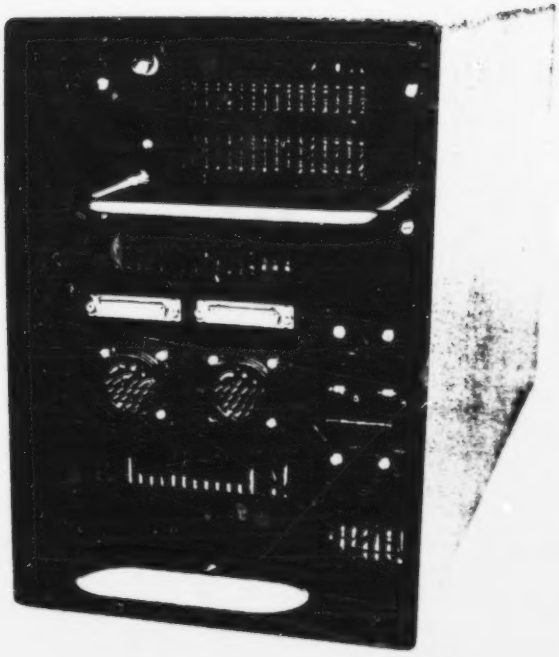
1.1 Objectives

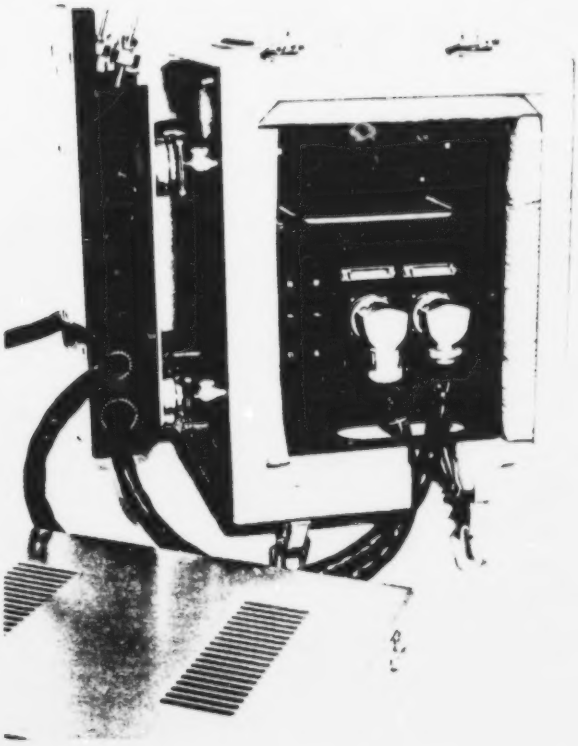
The overall objective is to improve the safety, energy efficiency and productivity of train operations through the development of train data, control and communication. The specific objective of Phase III is to provide engineering design support for the laboratory testing of

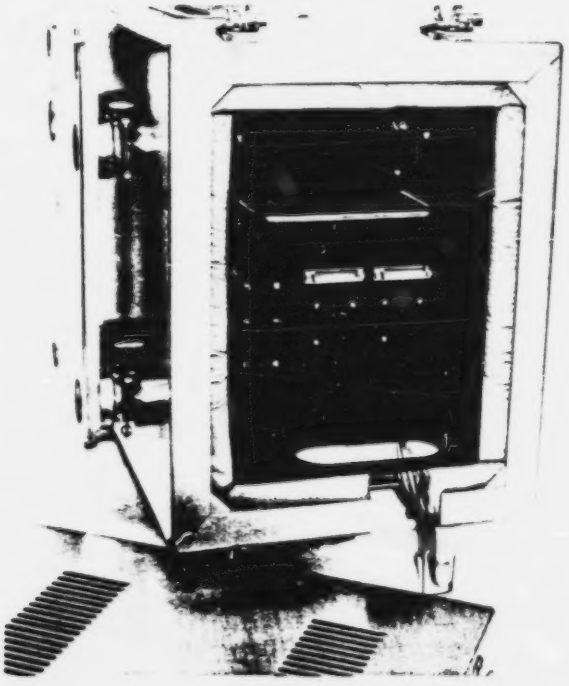
a prototype system and the field performance testing of a second system by Canadian Pacific Railway.

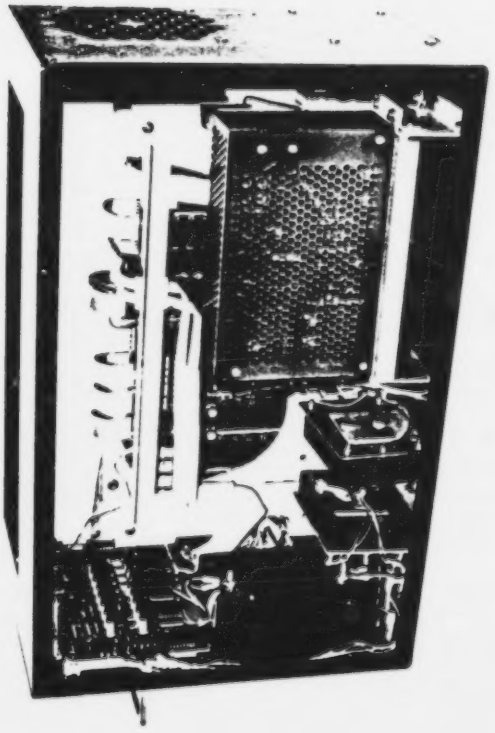
1.2 Scope

The third phase of the solid state micro-processor controlled train data recording system involves the necessary transport of system components to and from evaluation sites, training of personnel involved in the laboratory and field tests, necessary equipment re-design or modifications and software changes as dictated by the results of the performance evaluations.









2. PHASE III - FIELD TESTS AND LABORATORY SUPPORT

2.1 Work Statement

The following work was completed as Phase III of the project.

- Work plan, activity schedule, cash flow projection, project management control and documentation procedures.

- Engineering and technical support of prototype equipment at the Warnock-Hersey plant in Mississauga, Ontario.

- Engineering and technical support of prototype equipment installed in C.P. Rail locomotives and offices.

- Upgrade recorder program memory to 64K bytes for three recorders.

- Format all analog and digital signals for transmission over a RS232C link.

- Provide one light pen and associated cabling on one playback unit.

- Conduct functional tests of all components/systems that were re-designed, modified, or enhanced.

- Update all project documentation.

2.2 Environmental Laboratory Support

The recorder (Serial No. 1004) that underwent environmental testing at the Warnock-Hersey plant in Mississauga was returned to MPB Technologies Inc. for servicing. Several of the integrated circuits on each printed circuit board had corroded pins. Many pads on these boards had a deposit formed on them wherever the solder mask was not present. These deposits were removed with a brush and a solution of trichlorocthylene. Several days were expended in attempting to repair faulty printed circuit boards, but the effort was frustrating since many of the problems encountered were attributed to intermittant contact between the integrated circuits and their sockets. The rotor of the fan showed evidence of some surface rusting, but the fan, the circuit breaker, the pre-regulator and the power supplies were all operational.

The circuit boards should in future be sprayed with a commercially available elastoplastic silicone conformal coating to protect the electronic components and assemblies against moisture, corrosion, thermal stress and mechanical abuse.

During the environmental tests, 100 V.D.C. was accidentally connected to the 74 V.D.C. input of the recorder and the pre-regulator sustained damaged. MPB Technologies was informed of this and an attempt to determine the extent of damage was attempted over the phone. When it was determined that the module could not easily be repaired at Warnock-Hersey, it was returned and a replacement pre-regulator was sent to Warnock-Hersey.

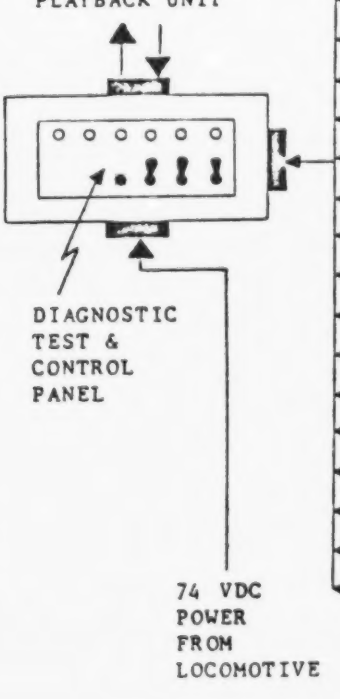
The power supply from the portable memory was returned to MPB Technologies Inc. Initial investigation showed that the over voltage protector circuit for the -12 volt supply was energizing. The problem was traced to a voltage regulator that nad a short circuit between the input and output terminals. The device was replaced and the power supply recalibrated and returned to Warnock-Hersey.

2.3 Field Trials

2.3.1 Low Voltage Battery Supply

Under normal operating conditions the recorder runs unattended, receiving its power from the locomotive batteries, even if the locomotive is shut down. One inconvenience that occured during the field trials occured only during cold weather. When the locomotive engine was started the battery voltage dropped to approximately 30 volts. The recorder was designed to work with a 74 V.D.C. nominal supply and will work with any battery voltage from 53 volts to 80 volts. As a result, all data that had previously been entered via the portable keyboard and also all data acquired previously, was lost. Hence the recorder, when it was interrogated a few days later did not show the correct date, but instead an elapsed time. The recorder also did not have any data in memory. This is because, when the battery voltage returned to normal, the recorder started up in the initialize mode. In this mode, data is displayed, but not recorded.

The above nuances were addressed in Phase IV of the program and solved by implementing a battery backed real time clock, battery backed



PARAMETER	TYPE	RECORDER TYPE BASIC	OPTION 1	OPTION 2
1. TIME (REAL AND ELAPSED)	RG	X	X	X
2. SPEED	PT	X	X	X
3. THROTTLE LEVEL	C	X	X	X
4. DYNAMIC BRAKE	D	X	X	X
5. BRAKE PIPE	A	X	X	X
6. INDEP. BRAKE	A	X	X	X
7. LOC. INIT. EMERG.	D	X	X	X
8. LD. UNIT PWR RED	D	X	X	X
9. SANDING	D	X	X	
10. WHISTLE	D	X	X	X
11. VIGILANCE	D	X	X	
12. LEADING/TRAILING	CM	X	X	
13. DISTANCE	PT	X	X	
14. TRACTION CURRENT	A	X	X	
15. WHEEL SLIP/CREEP	D	X	X	
16. BELL	D	X	X	
17. LOSS OF CONTIN. (LOCO)	D	X		X
18. SYSTEM POWER (LOCO)	D	X		X
19. MU MODE (LOCO)	D	X		X
20. INDEP. BRAKE (LOCO)	D	X		X
21. 10 KHZ CLOCK (LOCO)	D	X		X
22. PENALTY BRK (LOCO)	D	X		X
23. AUTO BRK (LOCO)	D	X		X
24. EQUAL. RESERV.	A	X		X
25. FORWARD	D	X	X	X
26. REVERSE	D	X	X	X

TYPE A EVENT = ANALOGUE MEASUREMENT
TYPE D EVENT = DIGITAL (ON/OFF) MEASUREMENT
TYPE C EVENT = CODED DATA
TYPE CM EVENT = CODED MESSAGE
TYPE PT EVENT = PULSE TRAIN
TYPE RG = RECORDER GENERATED VALUE

FIGURE 2 - LIST OF TRAIN OPERATING PARAMETERS

CMOS RAMS, and software changes to have the recorder start recording when power is applied.

2.3.2 Transient Protection Overload

As a result of experience gained in Phase I and Phase II of the program, it was decided to clamp transients on the signal input lines at the junction box. Transient voltage suppressors were installed on each signal input and the power lines. These transient absorption zeener diodes are guaranteed to short circuit if the peak pulse power is exceeded, thereby protecting the recorder equipment. Failures of these diodes were observed on January 18 in the junction box, corresponding to the following signals - leading/trailing, generator field relay and sanding (see Fig. 2). As a consequence of these diodes shorting, insultation was burnt off the signal wires near the respective relays. A current limiting resistor was installed in the signal path to alleviate the problem of these diodes overloading. (See Appendix 'A' for transient absorption zener specifications).

2.3.3 Traction Motor Current Shunt Failure

On June 6th the circuit board for the traction motor current shunt was removed from the locomotive after having performed without incident for eight months.

Visual inspection showed that five resistors had failed due to excessive power dissipation in them. Upon detailed inspection it was revealed that the analog ground plane had shorted through a rubber washer to a mounting stud that was electrically at the locomotive chassis potential. This caused a huge current flow through the input resistors and as a result they were burned. It is the author's opinion that

vibration and/or shock was responsible for this failure.

The problem was rectified by removing the ground plane from around the mounting holes so that it was not physically possible for either the stud or the nut to touch the ground plane. As an added precaution, insulating fibre washers are now being used instead of the compressible rubber washers.

3. CONCLUSION

Enhancements made to the recorder were a direct result of the experience garnered during the field trials. These improvements were implemented in hardware as well as software, and facilitated the use of the recorder from an operating standpoint. Since the recorder has the capability of being interrogated through the serial port, all signals and calculated values can be accessed either locally or (with the addition of a modem) remotely.

The preliminary results from the environmental laboratory indicate a vibrational resonance at 15 Hz. It has been suggested that the shock mounts be removed entirely to rectify this situation.

APPENDIX 'A'

MAXIMUM RATINGS

- 500 Watts of Peak Pulse Power dissipation at 25° C (see derating curve)
- $t_{clamping}$ (0 volts to BV min): Less than 1×10^{-12} seconds (theoretical)
- Operating and Storage temperatures: -55° to +130° C
- Forward surge rating: 70 amps, 1/120 second at 25° C
- Steady State power dissipation: 1.0 watt T_L = 75° C Lead Length = 3/8"
- Repetition rate (duty cycle): 01%

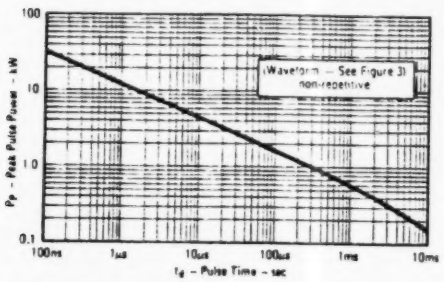


FIGURE 1
Peak Pulse Power vs Pulse Time

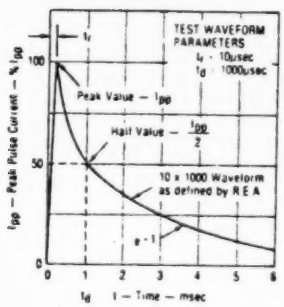

TEST WAVEFORM PARAMETERS
tr - 10μsec
td - 1000μsec
Peak Value — Ipp
Half Value — Ipp/2
10 x 1000 Waveform as defined by R.E.A.
100
50
0
Ipp — Peak Pulse Current — % Ipp
0 1 2 3 4 5 6
td t — Time — msec

FIGURE 3 — Pulse Waveform

ELECTRICAL CHARACTERISTICS @ 25°C

REVERSE STAND OFF VOLTAGE	BREAKDOWN VOLTAGE			MAXIMUM CLAMPING VOLTAGE @ I_{pp}	MAXIMUM PEAK PULSE CURRENT	MAXIMUM REVERSE LEAKAGE @ V_R	MAXIMUM VOLTAGE TEMPERATURE VARIATION
V_R VOLTS	BV @ VOLTS		I_T mA	V_C VOLTS	(Fig. 3) I_{pp} A	(Note 2) I_R μA	mV/°C
85	94.4 - 104.0		1	137	3.6	1	103

ELECTRICAL CHARACTERISTICS OF THE TRANSIENT VOLTAGE SUPPRESSOR